PATENT SPECIFICATION

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(54) A CRYOMEDICAL APPARATUS AND A METHOD OF OPERATING THE SAME

(71) We, DRAGERWERK AKTIENGESELLSCHAFT, a German company, of Moislinger Allee 53/55, 2400 Lubeck, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

According to one aspect of the present invention, there is provided a method of operating a cryomedical apparatus comprising supplying cold fluid to a cold-inducing tip of a probe of the apparatus to cool said tip, and subsequently supplying hot gas to said tip to heat said tip, said cold fluid being a liquid, and the supplying of said hot gas comprising leading the cold fluid in a gaseous phase to heating means, heating said cold fluid in a gaseous phase, and leading the hot gas produced to said tip.

According to another aspect of the present invention, there is provided a cryomedical apparatus, comprising a probe including a cold-inducing tip, and supply means connected to said probe and operable to supply cold fluid to said tip to cool said tip and subsequently to supply hot gas to said tip to heat said tip, said supply means comprising hot gas supply conduit means, a valve arranged to control the flow of said hot gas along said conduit means, a container for containing said cold fluid in a liquid phase and in a gaseous phase, and heating means for heating said cold fluid in said gaseous phase to produce said hot gas, said conduit means leading from a top part of said container.

An advantage of the invention is that there is no need for a separate gas source, *i.e.* a source additional to the liquid refrigerant. Since the heating of the tip of the probe is only required for a short period, the consumption of gas from the refrigerant is minimal.

Moreover, the provision of an electrical heating device in the region of the tip of the probe is not necessary, so that the risk of electrical shocks or burning effects on body tissue is avoided. The present invention is applicable to various types of probe, independently of the way in which cold is produced.

In an advantageous constructional form, the hot gas supply conduit means opens into a refrigerant supply duct. This kind of construction has been found particularly simple and advantageous.

In order that the invention may be clearly understood and readily carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:—

Figures 1 and 2 show a diagrammatic, longitudinal sectional view, and a section taken on the line II-II of Figure 1, respectively, through a cryomedical apparatus,

Figures 3 and 4 show fragmentary views, otherwise similar to Figures 1 and 2, respectively, of a modified version of the apparatus,

Figures 5 and 6 show views similar to Figures 3 and 4, respectively, of another modified embodiment of the apparatus, and

Figures 7 and 8 show views similar to Figure 3 of respective further modified versions of the apparatus.

The cryomedical apparatus which is shown in Figure 1 comprises a closed, vacuum-insulated, storage container 1 for a liquid refrigerant, flexible supply tubing 2 for the supply and discharge of the refrigerant, a probe 3 securely connected to the flexible tubing 2 and having a cold-inducing tip 4, and a control and monitoring unit 5.

The storage container 1 with the refrigerant forms by natural evaporation a gaseous cushion 6 at a positive pressure. On opening of an electromagnetic valve 7 positioned in the bottom part of the storage container 1, the refrigerant flows through a supply duct 8 into the cold-inducing part 4 of the probe 3, where the liquid evaporates, produces cold in so doing, and is discharged as cold gas through a return duct 9, the cold gas es-

caping into the ambient atmosphere through an electro-magnetic valve 10. The return duct 9 is formed by the supply duct 8 and a flexible tube 11 encircling the duct 8 coaxially.

At the same time, refrigerant in its gaseous phase is discharged from the cushion 6 in the top part of the storage container 1 through a conduit 12 and is heated by a heating element 13 the temperature of which is monitored by means of a thermostat 14. The hot gas passes through a conduit 15 into an annular jacket 16 which is formed by the tube 11 and an external cylindrical wall 17. This jacket 16 is provided longitudinally with partition walls 18 which terminate just short of the right-hand end of the jacket 16 in Figure 1, so that the hot gas, entering in the region of the left-hand end of the jacket 16, flows through one half of the jacket 16 from the storage container 1, through 12, 13 and 15 to the tip 4 and then through the other half of the jacket 16 from the tip 4 to the valve 10. In this way the external walls 17 of the tubing 2 and of the non-cold-inducing part of the probe 3 are held at ambient temperature. The partition walls 18 are shown only in Figure 2.

When the cold-inducing process is to be ended, the electromagnetic valve 7 is closed. As a result the flow of liquid refrigerant into the tip 4 of the probe 3 is stopped. To heat the tip 4 of the probe 3, an electromagnetic valve 19 is opened, whereby hot gas passes through a supply conduit 20 directly into the tip 4 of the probe 3, heats the tip 4 and escapes into the ambient atmosphere through the return duct 9 and the electromagnetic valve 10. To end the heating operation, the electromagnetic valves 10 and 19 are closed and as a result the hot gas supply is completely stopped.

In the tip 4 of the probe 3 there is situated a temperature sensing device 21 the signal from which is indicated by an indicating instrument 22 at the control unit 5. A desired cold temperature for the tip 4 can be preset with a control knob 23 and is maintained by automatic opening and closing of the electromagnetic valve 7. The temperature of the heating element 13 is monitored by the thermostat 14, the signal from which is indicated by an indicating instrument 24. Its desired value can be preset with a control knob 25. A further indicating instrument 26 indicates the state of the refrigerant in the storage container 1. A manual switch 27 determines the operating state of the apparatus and has two positions, for hot and cold, respectively. In another constructional form not illustrated, the operating state is determined by a foot switch.

In the version shown in Figures 3 and 4, the flexible tubing 2 and the probe 3 are two separate units which can be releasably attached together at 28. The supply duct 8 for the refrigerant projects into the cold-inducing tip 4 of the probe 3, and the gas liberated in evaporation is returned through the return duct 9, formed by the duct 8 and the tube 11. The tube 11 forms with a tube 29 an annular jacket 30 through which the hot gas flows and prevents penetration of cold to the external wall 17 of the tubing 2. In this jacket a partition wall 31 and the conduit 20 are arranged. The partition wall 31 stops short of the right-hand end of the jacket 30 in Figure 3, so that it is ensured that hot gas will flow completely through the jacket. At its right-hand end the jacket is closed. Provided for preventing penetration of cold to most of the external cylindrical wall 32 of the probe 3 is a further hot gas supply conduit 33 which, when the flexible tubing 2 is fitted to the probe 3, projects into an annular jacket 34 of the probe 3 which is bounded by the wall 32. When the flexible tubing 2 is fitted to the probe 3 the projecting end of the conduit 33 is introduced into a sealing ring 35 of the probe 3. The hot gas flows through the jacket 34 and keeps the wall 32 at ambient temperature.

Arranged in the jacket 30 is the hot gas supply conduit 20 through which the hot gas for heating the tip 4 of the probe 3 flows. This tube opens at 36 into the refrigerant supply duct 8. When the cold-inducing process is ended, the supply of liquid through the duct 8 is ended and hot gas is introduced through the conduit 20, so that the tip 4 of the probe 3 is heated. Both the hot gas which flows through the jacket 34 and also the hot gas which is introduced through the conduit 20 to the tip 4 of the probe 3, flow out through the annular duct 9.

The version shown in Figures 5 and 6 differs from that shown in Figures 3 and 4 only in that the annular jacket 30 ends as early as the point 37. In this way the annular jacket 34 for guiding the hot gas for the external cylindrical wall 32 is formed by the wall 32 itself and the tube 11.

The embodiment shown in Figure 7 differs from those shown in Figures 3 to 6 in that the supply duct 8 ends in a releasable coupling 8*a* and the further guiding of the liquid refrigerant is effected through a supply duct 8*b* which is permanently fixed, in a manner not shown in detail, within the probe 3. The tube 11 which bounds the gas return duct 9 also ends in a releasable coupling 11*a*. The tube 11 is continued by a tube 11*b* which is also permanently fixed

to the probe 3.

In the version shown in Figure 8 the heating element 13 is arranged in the region where the flexible tubing 2 is attached to the probe 3. In this heating element 13, which is in the form of a gas-pervious sintered body for example, the cold gas flowing back from the cold-inducing tip 4 through the return duct 9 is heated. The hot gas so produced is discharged through an annular jacket 40 between the refrigerant supply duct 8 and the external wall 17 of the flexible tubing 2, and keeps this wall at ambient temperature. The gas supply conduit which is designated 12 in Figure 1 and connects the gaseous cushion 6 with the heating element 13 is extended in the version shown in Figure 8 through the tubing 2 to just beyond the heating element 13. The gas within the conduit 12 is heated both when flowing in the jacket 40 and also when flowing through the heating element 13 and, when required, is introduced at 36 into the supply duct 8. A further hot gas supply conduit 38 is provided which extends through the heating element 13 into the right-hand end in Figure 8 of an annular jacket 39 formed by the tube 11 the wall 32. The hot gas issuing from this supply conduit 38 keeps the wall 32 at ambient temperature. In this version shown in Figure 8 the flexible tubing 2 can be made considerably thinner and more flexible, since no separate gas discharge duct and heating jacket have to be provided as in the previous versions. With adaptation of the constructional elements shown in Figures 3 to 7, this version also may employ a releasably coupled probe.

The apparatus described with reference to the accompanying drawings is also that described in our co-pending Patent Application No. 54842/73 (Serial No. 1 443 070).

WHAT WE CLAIM IS:—

1. A method of operating a cryomedical apparatus, comprising supplying a cold fluid to a cold-inducing tip of a probe of the apparatus to cool said tip, and subsequently supplying hot gas to said tip to heat said tip, said cold fluid being a liquid, and the supplying of said hot gas comprising leading the cold fluid in a gaseous phase to heating means, heating said cold fluid in a gaseous phase, and leading the hot gas produced to said tip.

2. A method as claimed in claim 1, and further comprising utilizing the hot gas to prevent the cold of said cold fluid from penetrating to an exterior part of said apparatus.

3. A method as claimed in claim 2, wherein said heating means is disposed at a region where flexible tubing carrying said cold fluid is attached to said probe, and said hot gas is utilized to prevent said cold from penetrating to an exterior part of said tubing.

4. A method as claimed in claim 1, 2, or 3, wherein said cold fluid in said gaseous phase is led to said heating means from a top part of a container containing said cold fluid in its liquid phase.

5. A cryomedical apparatus, comprising a probe including a cold-inducing tip, and supply means connected to said probe and operable to supply cold fluid to said tip to cool said tip and subsequently to supply hot gas to said tip to heat said tip, said supply means comprising hot gas supply conduit means, a valve arranged to control the flow of said hot gas along said conduit means, a container for containing said cold fluid in a liquid phase and in a gaseous phase, and heating means for heating said cold fluid in said gaseous phase to produce said hot gas, said conduit means leading from a top part of said container.

6. An apparatus as claimed in claim 5, wherein said supply means further comprises cold fluid supply duct means, and said conduit means opens into said duct means.

7. An apparatus as claimed in claim 5 or 6, wherein said supply means further comprises a thermostat arranged to control said heating means.

8. An apparatus as claimed in claim 5, 6 or 7, wherein said supply means comprises flexible tubing attached to said probe, and said heating means is disposed in the region where said tubing is attached to said probe.

9. An apparatus as claimed in any one of claims 5 to 8, and further comprising jacket means arranged to receive said hot gas from said supply means and thereby to prevent penetration of cold from said cold fluid to an external part of said apparatus.

10. A method of operating a cryomedical apparatus, substantially as hereinbefore described with reference to Figures 1 and 2, Figures 3 and 4, Figures 5 and 6, Figure 7, or Figure 8, of the accompanying drawings.

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1443069 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

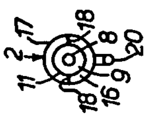

FIG.2.

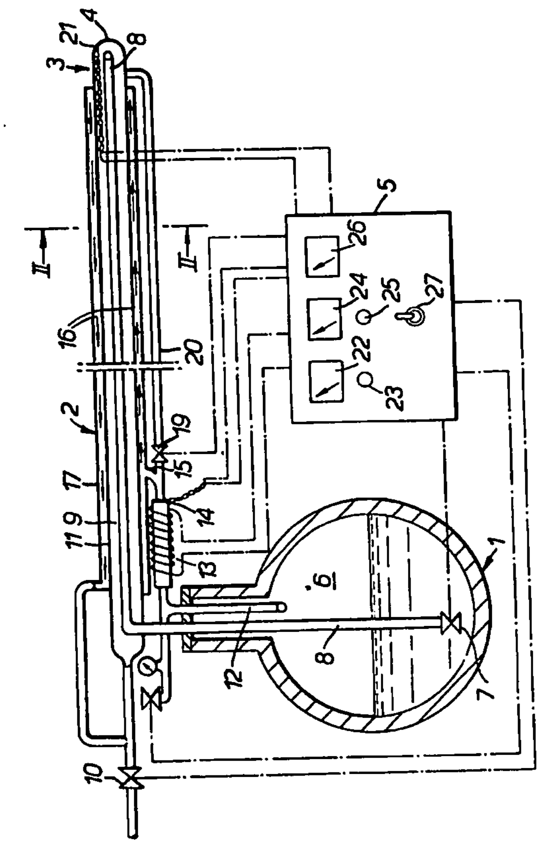

FIG.1.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

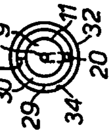

FIG.4.

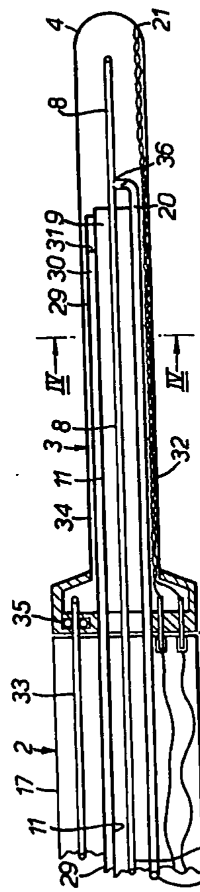

FIG.3.

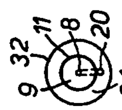

FIG.6.

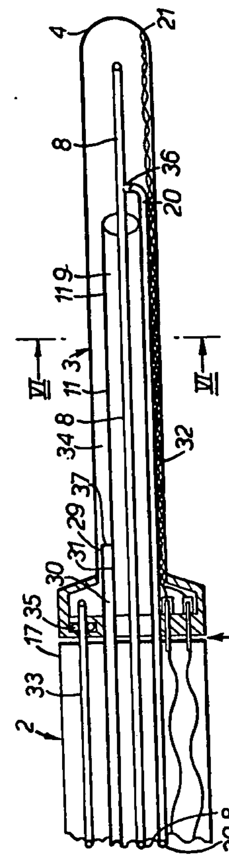

FIG.5.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

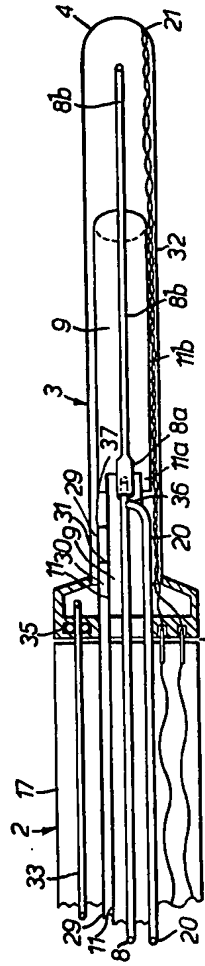

FIG. 7.

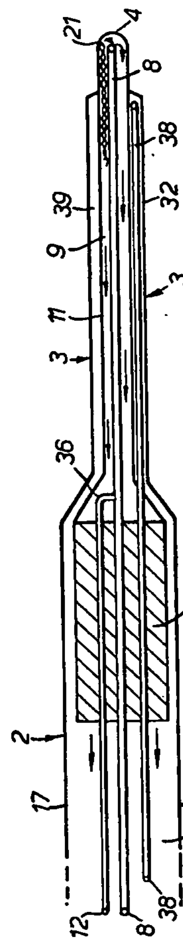

FIG. 8.